Flight Systems Research Quarterly

An informal newsletter by and for participants of the UCLA/NASA Flight Systems Research Center

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Summer Research Opportunities at NASA Dryden

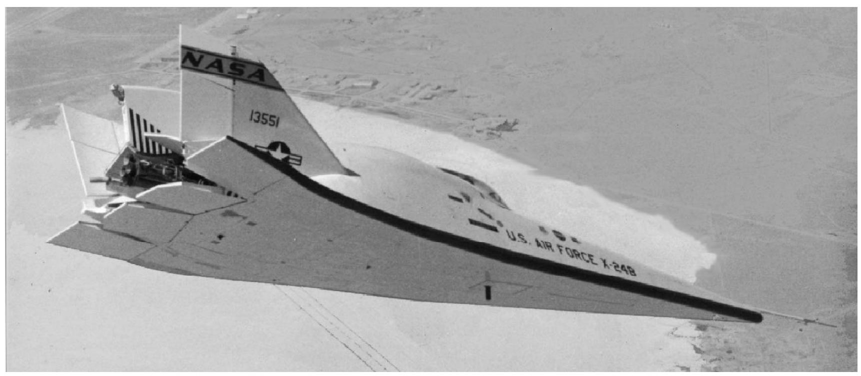
As part of the joint NASA Dryden/ UCLA Flight Systems Research Center cooperative agreement, graduate student researchers associated with the FSRC can take advantage of the many resources and facilities at Dryden while still being students at UCLA. As summer approaches, FSRC graduate students are encouraged to consider the possibility of conducting some of their research on-site at Dryden. The benefits of such an arrangement include gaining hands-on experience into flight-related research, interaction with Dryden engineers who can assist students in various aspects of their research, use of Dryden's computational or experimental facilities, or simply gaining a better definition and understanding of their thesis/dissertation area by exposure to real-world technical and engineering challenges confronting the broad field of flight systems.

Last summer, seven UCLA students undertook research efforts full-time at Dryden, while living in the Antelope Valley communities of Lancaster and Palmdale (one hour north of LA). This year, stipend funding for living away from Westwood is again available, though more limited than last summer. Students who are interested in such an arrangement should contact the FSRC Associate Director, Dr. Ken Iliff, at 805-258-3314 as soon as possible. Though a daily commute between Edwards AFB and UCLA would be difficult, students unable to relocate may want to consider commuting on a limited basis (e.g., once or twice a week) or perhaps carpooling with other FSRC participants. Driving costs may be reimbursable through your research grant; see your academic department.

Of Championships and Eras

It's big news, and deservedly so. The UCLA Bruins are the 1995 NCAA Basketball Champions, and an unprecedented eleventh national title banner now hangs in Pauley Pavilion. It's been a long 20 year wait in Westwood, and with all the talk of "the last time UCLA won an NCAA basketball championship...", it might be interesting to know what was happening 100 miles north of Westwood when the Wizard last led the Bruins to the national title, bringing the glorious Wooden Era to a close.

20 years ago, NASA Dryden was experiencing its own "end of an era". Up until 1975, what put Dryden and Edwards AFB on the map was still going on: the postwar rocket research program. Starting with the sonic boom of the Bell X-1, piloted by Chuck Yeager in 1947, NASA Dryden went on to support the flight testing of a myriad of piloted rocket aircraft. And in the Spring of 1975 (while the Bruins were giving the Kentucky Wildcats a lesson in basketball), the sound of an XLR-11 rocket engine could still be heard over Edwards in the form of the Martin X-24B lifting body.



The X-24B was air-launched from a B-52, and would rocket up to supersonic speeds and high altitudes before gliding back for a landing. Research from the X-24B proved the operational feasibility of making unpowered landings onto a concrete runway (not just the lake bed) within acceptable touchdown accuracies, paving the way for how the Space Shuttle would make its future landings.

Later that same year, the X-24B program concluded, having attained all its various flight objectives, bringing the Dryden/Edwards AFB rocket plane era to a close. Other Dryden research programs going on back in 1975 included the YF-12A and YF-12C, which were essentially SR-71s, the F-111 TACT (Transonic Aircraft Technology), the F-8 DFBW (Digital Fly-by-Wire), the F-15 and F-15 RPRV (Remotely Piloted

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New sites of interest on the Dryden WWW home page.

Research summaries were once again submitted by graduate students and/or their professors. Project titles and NASA monitors are listed alongside.

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Research Vehicle), and a series of 747/ L-1011 wingtip vortex studies.

What began for Dryden back in 1947 was really also a beginning for UCLA, for that was the year John Wooden attended his first Final Four, albeit as a spectator; but he would be back, again, and again, and again. In 1975, the rocket era passed on along with the Wooden era, but just as 1995 has seen the potential for the start of something big again in Westwood, perhaps there might be a similar sense of hope and anticipation waiting for Dryden aeronautics.

In spite of NASA down-sizing and the aerospace bust in Southern California, the X-33 and X-34 development programs provide a ray of hope. Design progress continues to go forward at the Lockheed Advanced Development Company in Palmdale, McDonnell Douglas Aerospace in Huntington Beach, and Rockwell International Corporation, Space Systems Division in Downey (Orbital Sciences Corporation of Dulles, VA is working with Rockwell on the X-34). Both X-planes will demonstrate the advanced technologies (eg. hypersonic flight) and operational management techniques needed for the next generation of reusable launch vehicles, and thus provide research for an eventual Shuttle follow-on. Not unlikely, the X-33 and X-34 flight tests will be conducted at NASA's premier flight test center, Dryden. Though it may be wishful thinking to think that the "glory days" of rocket aircraft may be back again, just as it may be to think the Bruins will win 9 more national championships in the next 11 years, there is still good reason to be excited about what lies ahead in the world of cutting-edge, experimental flight testing and research.

FSRC Research Roundup

Analytical Redundancy, Fault Detection, and Health Monitoring for Aircraft
Walter Chung
Prof. J. Speyer (MANE) **Ken Iliff (X)**

A Health Monitoring System is an autonomous network of sensors and microprocessors which checks a vehicle for anomalies and subsystem failures. There are many different facets to the health monitoring process. Among these are failure detection, failure identification, and system reconfiguration after identification. At UCLA, we have been focusing on the first two aspects (detection and identification) via a special type of observer known as a Beard-Jones Detection Filter.

Currently, we are looking at ways to apply robust estimation theory to Detection Filter design and at the use of Detection Filters as a part of a health monitoring system for aircraft structures. These two thrusts are complementary. Aircraft structures are complex systems which are challenging to model and analyze. Robustifying the Detection Filter will enable the engineer to account for disturbances and modelling uncertainties early in the design stage. The structure of robust estimators, moreover, is ideal for their incorporation into decentralized networks which are likely to be needed for distributed-parameter systems such as aircraft structures. Decentralized networks, in fact, were the early focus of this research and the results of these efforts will be presented this June at the 1995 American Controls Conference in a paper entitled "A General Framework for Decentralized Estimation."

Leading Edge Cooling Studies
Gustave Stroes
Prof. I. Catton and Prof. V. Dhir (MANE) **Bob Curry (XRA)**

Work continues in the area of grooved capillary structures. Experimental results comparing triangular and sinusoidal inclined liquid filled groove performance were presented in a paper at the ASME/JSME Joint Thermal Engineering Conference in Maui last March. The paper is titled: "An Experimental Study of the Heat Removal Capabilities of Triangular vs. Sinusoidal Capillary Channels". A second paper will be presented at the International Heat Pipe Conference in Albuquerque this May. The results here compare a one dimensional model for the triangular groove geometry with corresponding experimental data. The agreement between model and experiment is within 15% for all cases.

Recent work has used fiber optic probes and an Argon Ion laser in order to investigate the shape of the liquid-vapor interface in the groove, both in the axial and cross-sectional directions. It has been found that the profile in the axial direction is roughly parabolic for the sinusoidal shape and linear for the triangular geometry. The cross-sectional profile is always circular (ie. the radius of curvature is constant across the groove). This is valuable information since the semi-analytical models that have been developed require knowledge of both these profiles. Now it is no longer necessary to assume the profiles without justification.

Hypersonic Panel Flutter
Ira Nydick
Prof. P. Friedmann (MANE) **Kajal Gupta (XR)**

The general equations describing the nonlinear fluttering oscillations of shallow, curved, heated orthotropic panels have been derived. The formulation takes into account the location of the panel on a generic hypersonic vehicle. Computer solutions are obtained using Galerkin's method combined with direct numerical integration in time to compute stable limit cycle amplitudes. Results have been obtained for

Web News

New items are constantly being added on the Dryden World Wide Web home page. The FSRQ newsletter will soon be available on the Dryden server, under the Educational Programs page; this should be ready by the summer.

There is a new page for the Environmental Research Aircraft and Sensor Technology (ERAST) flight project, which includes the APEX Low-Reynolds Number Flight Experiment (see Flight Systems Research Quarterly, Vol. 1, Issue 4); URL to http://www.dfrc.nasa.gov/Projects/ERAST/ERAST.html.

Dryden's External Affairs Office also posts the latest press releases in addition to Dryden's monthly newsletter, the X-Press. In the last three X-Press issues (February, March, and April), there have been three different articles by NASA Administrator Daniel Goldin, each of them stressing that tomorrow's NASA will be different from NASA today. Goldin is committed to President Clinton and Vice President Gore's challenge to "reinvent government" by reducing expenditures, streamlining, downsizing, and restructuring. These messages will be of interest to anyone wondering where NASA will be going in the next few years; URL to http://www/dfrc.nasa.gov/EAO/X-Press/x-press.html. The UCLA WWW home page has a new look which should make browsing easier; URL to http://www.ucla.edu.

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*(**Research Review**; continued from page 2...)*

isotropic and orthotropic simply supported panels for two curvature models and various temperature distributions. Future research efforts will focus on deriving a structural model of the wing/fuselage system and designing an optimal controller for flutter suppresion in the hypersonic regime.

Numerical Modeling of Atmospheric Transients for High Performance Aircraft

Anindita Datta, Daniel M. Landau, and Robert D. Sharman
Prof. M. Wurtele (Atmos. Sci.) L. Jack Ehernberger (XRA)

We are continuing with our research into the vertical propagation of gravity-inertia (GI) waves. The behavior of these disturbances is different, depending on whether or not a critical level exists in the flow field. Propagating upward toward a critical level, the GI lee wave--unlike its pure gravity counterpart--does not breakdown, but propagates downstream increasingly dominated by inertial effects. This is subject to linear treatment, and we have derived the first relatively simple approximate analytic solution for the steady-state disturbance.

We have written a chapter for Annual Reviews of Fluid Mechanics, and are presenting one invited and one contributed paper to the AMS meeting on mountain meteorology in August.

Modeling of High Mach Number Flows for Pegasus

E. David Huckaby and John Mendoza
Prof. I. Catton (MANE) Bob Curry (XRA)

As suggested during last October's NASA/UCLA Research Review, the computational fluid dynamics (CFD) code PARC3D and the Engquist filter were tested against more controlled experimental conditions than those in the Pegasus flights. They were applied to the two-dimensional shock/laminar boundary-layer interaction problem.

Two experimental conditions were simulated--an unseparated and a separated case. There were three simulations for each case. They were: 1) zero artificial dissipation with filter, 2) full artificial dissipation with no filter, and 3) zero artificial dissipation with no filter. The experimental data consisted of skin friction and pressure readings recorded by Hakkinen, R. et al. (1959). For the skin friction, no negative values were recorded due to limitations of the experimental apparatus. Thus, for the separated case, the analysis is centered on the ability of PARC3D to estimate the point of separation and reattachment of the boundary layer. In both cases, the filtered solutions tended to steepen the velocity gradients resulting in an overprediction of the skin friction. Furthermore, for both skin friction and pressure, the filtered solutions were the least accurate of the three simulations. The other two simulations followed the experimental data very well. In the separated case they both captured the separation location but underpredicted the reattachment point. It was found that for the shock strengths investigated, the two simulations without the filter displayed very similar results due to the absence of large pressure gradients which dictate usage of artificial dissipation. However, for a stronger shock strength, major differences in their solutions were seen. Also, for this case, the ability of the filter to suppress numerical fluctuations resulted in the best approximation of the experimental data among the three simulations. This is largely attributable to a shock which was better aligned with the flow direction than in the Pegasus simulations. Thus, as concluded in the Research Review, care must be taken in choosing values for the artificial dissipation. Also, the filter is best suited for grids with little skewness.

(Continued on the back page)

FSRC Research Roundup - *continued*

Modeling and Development of a Lobed Injector/Burner for NOx Reduction in High Speed and Advanced Subsonic Aircraft

In-Flight Imaging of Transverse Jet and Lobed Injector Mixing Processes

Lance L. Smith, Timothy J. Gerk, Olivier Delabroy, Ivan Lam, Ari Majamaki
Prof. A.R. Karagozian and Prof. O.I. Smith (MANE)
Al Bowers (XRA) and Ken Iliff (X)

Analytical and experimental studies of a lobed fuel injector are continuing in the MANE Combustion Laboratory at UCLA. The injector is made of two plates which are planar and parallel at the upstream edge, and corrugated at the downstream edge. Fuel flows through the small space between the plates, while air flows over the external surfaces.

Smoke flow visualization reveals that the injector produces streamwise vorticity downstream of the injector, stretching the interface between fuel and air. Planar Laser Induced Fluorescence images of acetone (our fuel tracer) quantify the degree of mixing and scalar dissipation during this stretching process. We find that mixing is 80 percent complete before scalar dissipation rates fall below the level required for extinction of a propane-air flame. Thus, we expect that fuel-air mixing will occur under conditions of flame extinction, resulting in a partially premixed, lean, low-NOx flame downstream of the region of most intense mixing.

Flame extinction (ignition delay) is modeled analytically for the lobed injector geometry, where a "strip" of fuel is sandwiched between surrounding air and stretched. The model demonstrates that one of three different conditions may occur, depending on the rate of stretch and the thickness of the fuel strip. Two "twin" flames may ignite, one at each fuel-air interface, for thick layers and small strain rates. A single flame may ignite at the strip center, for thin layers or high strain rates. At very high strain rates flame extinction prevails, and ignition does not occur. We find that for fuel strips the critical strain rate for ignition prevention is 20 percent smaller than for single fuel-air interfaces. The fuel strip geometry thus provides greater ignition delay times and longer blow-off distances.

In February, Dryden's Bob Curry, Greg Noffz, and David Richwine (PRC Inc.) were on hand at UCLA for a meeting to discuss the design and implementation of the planned in-flight lobed injector experiments. The flight experiments will be performed on Dryden's F-15B Aerodynamic Testbed Aircraft, utilizing a second generation flight test fixture (FTF2).

{The next call for research summaries will be in late summer, to be published in the Summer/Fall '95 FSRQ newsletter; good luck on your summertime research!}